Data Visualization in R with ggplot2::

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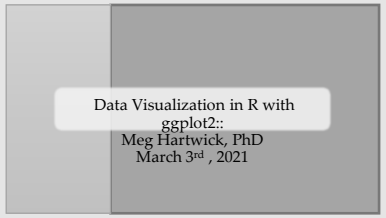
Workshop Overview

Materials Available at:

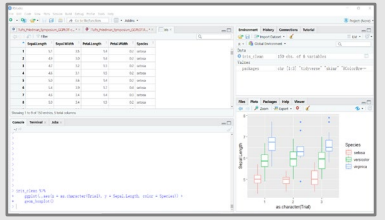
https://github.com/meghartwick/ggplot2-Workshop

- PowerPoint Slides



- HTML
  - https://rpubs.com/meghartwick/733550

- Notebook and Code



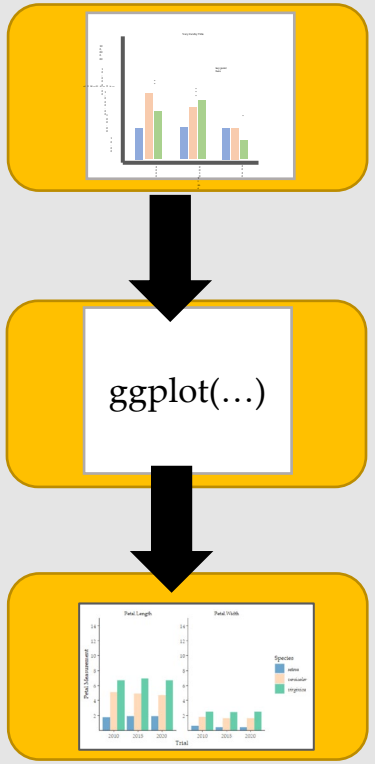
Workshop Overview

Flow

I. Foundation - Concept Review

II. Structure – ggplot2:: syntax

III. Application – Sketch to Story



Workshop Overview

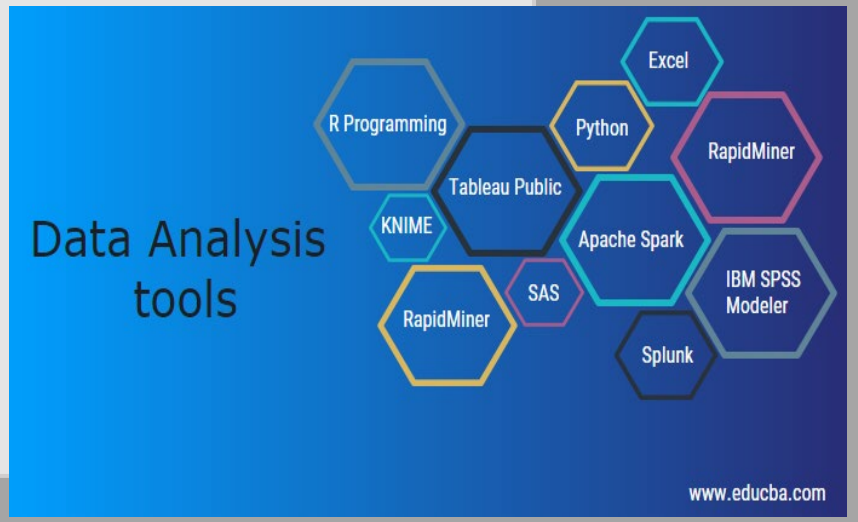
Why do you usually make graphics?

1. For your own use.
2. Informal sharing with colleagues.
3. For formal presentations or publication.

Workshop Overview

How do you usually make graphics?

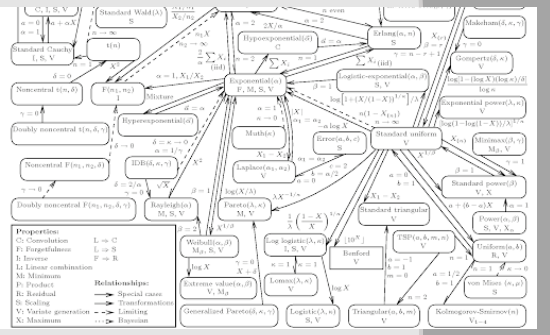
1. Quick-and-dirty (excel).
2. Just OK (statistical software, eg: JPM, SAS).
3. Refined (Tableau, base R, some ggplot2).
4. Highly refined (R and Python Pro).



Workshop Overview

What makes for a good graphic?

1. Really busy with every detail in text…



2. Flashy, pleasing?

3. A clear message that tells a story

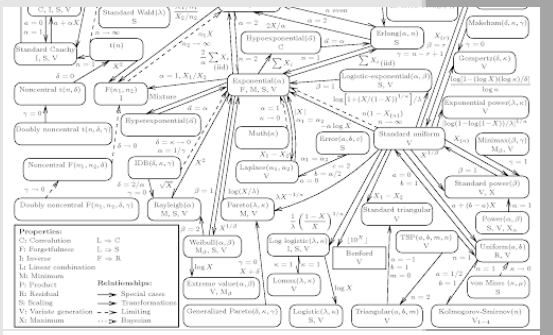
Workshop Overview

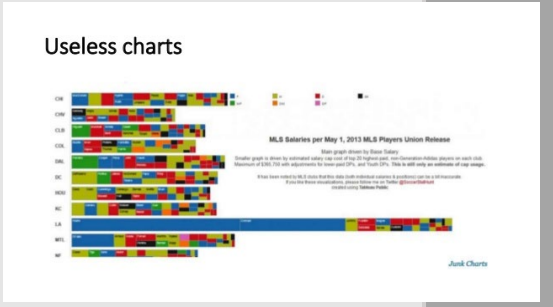
What makes for a good graphic?

1. Really busy with every detail in text…

2. Flashy plotting…

3. A clear message that tells a story





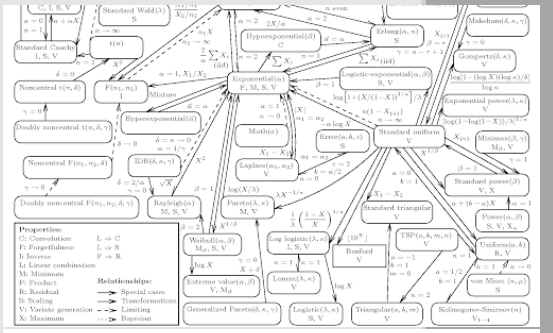
Workshop Overview

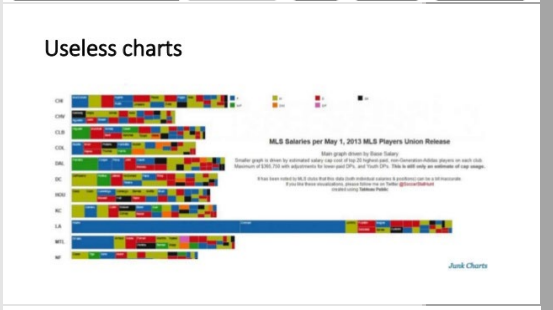
What makes for a good graphic?

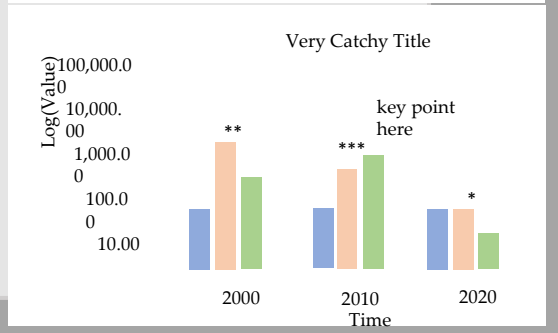
1. Really busy with every detail in text…

2. Flashy plotting…

3. A clear message that tells a story…



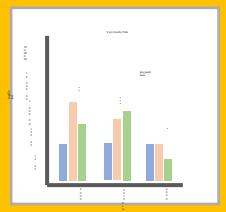




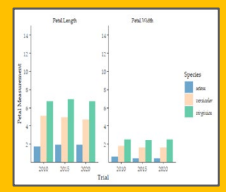
Workshop Overview

Today's Goal

- Understand how to develop graphics that:
  - Effectively tell a story
  - In ggplot2 (and some tidyverse)
  - Are refined or highly refined.



ggplot(…)



I. Foundation

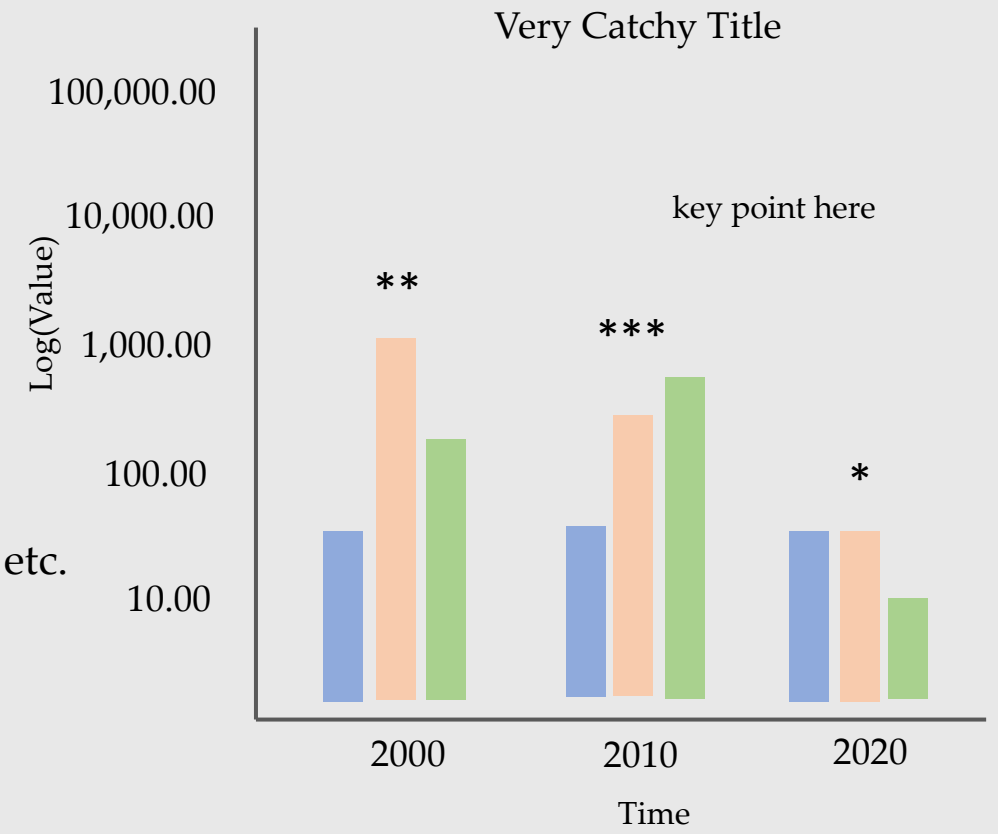
1. Concepts

2. Tidyverse

3. ggplot2::

Foundations and Concepts Refresher

1. Data
   - Structure
     - Continuous
     - Discrete
   - Format
     - Wide
     - Long
2. Graph Attributes
   - Dimension
   - Axes scale
   - Symbols, color schemes etc.
3. Key Elements
   - Title
   - Axes labels
   - Embedded comments



I. Foundation

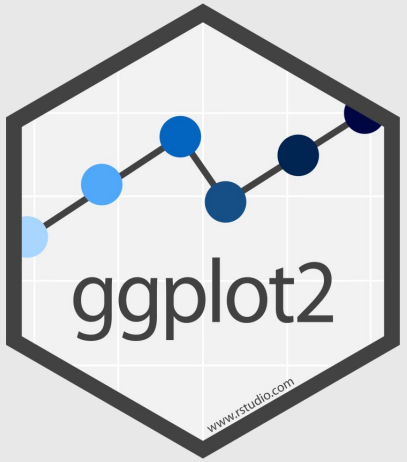
Tidyverse

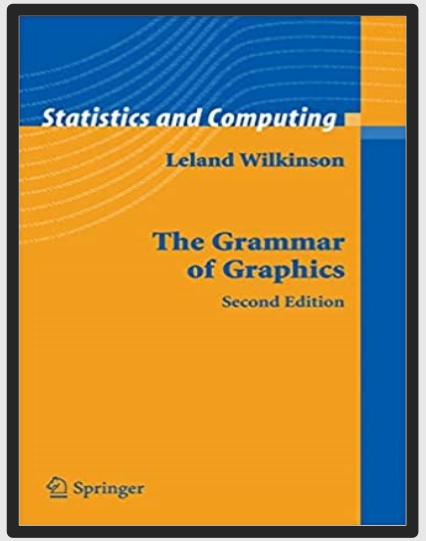
- Originally ‘Hadleyverse’
- Collection of R packages with shared:
  - Philosophy
  - Structure
  - Syntax
- Package ‘piping’ (%>%)
  - Functions act as verbs
- Over 27 packages including:
  - *readr* – importing data
  - *dplyr* – data cleaning
  - *ggplot2* – data visualization
  - *lubridate* – working with dates
  - *stringr* – working with strings

I. Foundation

ggplot2::

- Developed by Hadley Wickham
- 10+ years old
- Readability > base R plot
- Over 84 extensions
  - *ggtext*
  - *ggthemes*
  - *gganimate*
  - *esquisse*
- 'Grammer of Graphics'
- 8 main class of functions
  - align with key elements and attributes of graphics communication





II. Structure

Foundations

1. Data
   - Structure
     - Continuous
     - Discrete
   - Format
     - Wide
     - Long
2. Graph attributes
   - Dimension
   - Axes scale
   - Symbols, colors etc.
3. Key elements
   - Title
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ggplot2:: Syntax

1. Data
2. Function
3. Coordinates
4. Mapping
5. Geometries
6. Scales
7. Facets
8. Themes

1. **Data**
2. **Function**
3. **Coordinates**
4. **Mapping**
5. **Geometries**
6. **Scales**
7. **Facets**
8. **Themes**

II. Structure

ggplot2::

- Slides
  - Code - How the element is called
  - Considerations – some assumptions to keep in mind
  - Arguments – How, when, what to use
- HTML
  - Follow along with the code and graphics
- Notebook and Code
  - Run code as source code or chunks

II. Structure

1. **Data**
2. Function
3. Coordinates
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df %>%

II. Structure

df %>%

- Considerations
  - Discrete or Continuous data for coordinates
  - Discrete or Continuous metadata for mapping
  - Missing Data etc.
  - Tidyverse can be really useful here
    - data transformations
    - df reshaping
  - Structure check
    - skimr::skim()
- Arguments
  - Date can be piped to function or called within

```
skimr::skim(df)

df %>% dplyr::filter() %>% dplyr::pivot()
```

II. Structure

df %>%

- Considerations
  - Discrete or Continuous data for coordinates
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Foundation: Graph Data

```
skimr::skim(df)

df %>% dplyr::filter() %>% dplyr::pivot()
```

II. Structure

1. Data
2. **Function**
3. Coordinates
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```
df  %>%
ggplot(...) +
```

II. Structure

ggplot(…) +

- Consideration
  - Calls the plot object
  - Best placement of df for plot development

- Arguments
  - Data =
  - Coordinates =
  - Mapping =

```
ggplot(df, aes()) + …
ggplot(df) +
ggplot() +
df %>% ggplot(., aes()) +
```

II. Structure

1. Data
2. Function
3. **Coordinates**
4. Mapping
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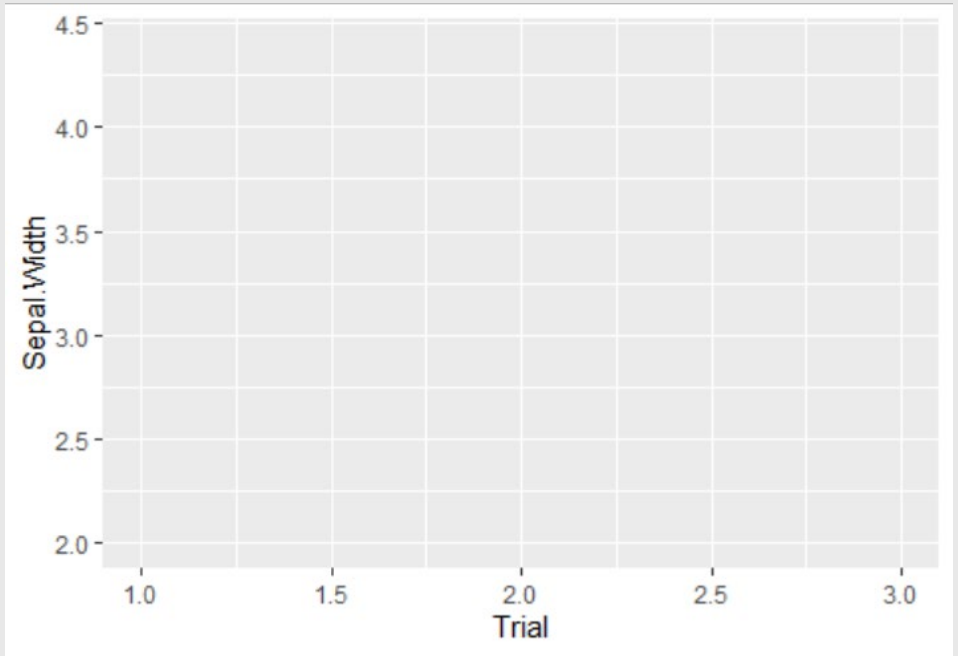
```
df  %>%
ggplot(., aes(x = x, y = y, ...)) +
```



II. Structure

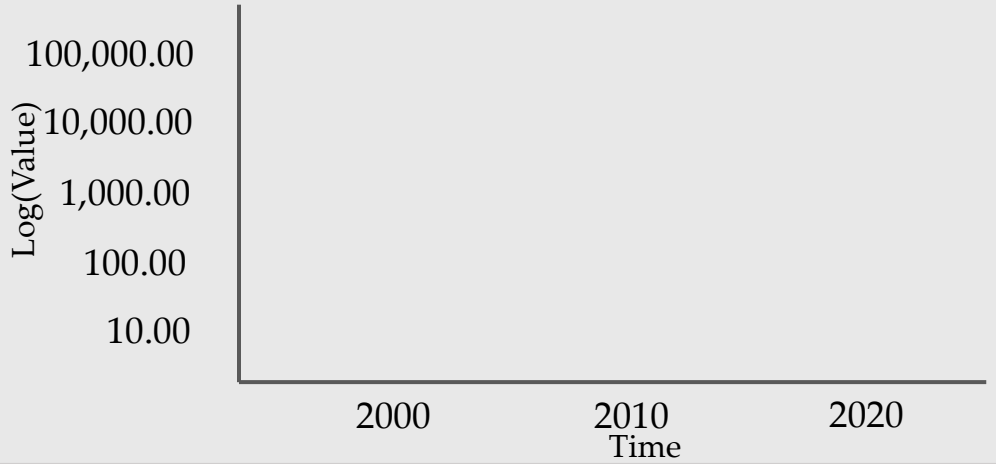
ggplot(., **aes(x = x, y = y**, …)) +

- Considerations
  - Data positions for plot
  - Not necessary to specify here, but must be supplied in plot layers
  - Continuous Data
    - Coordinate according to the data
  - Discrete Data
    - At 1, 2, 3 etc. on axis
    - Alphabetical for character class
    - Level for factors class

II. Structure

ggplot(., **aes(x = x, y = y**, …)) +

- Arguments
  - x =
  - y =
  - positional, not necessary to specify
  - for geometries that use count, y not accepted



II. Structure

1. Data
2. Function
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4. **Mapping**
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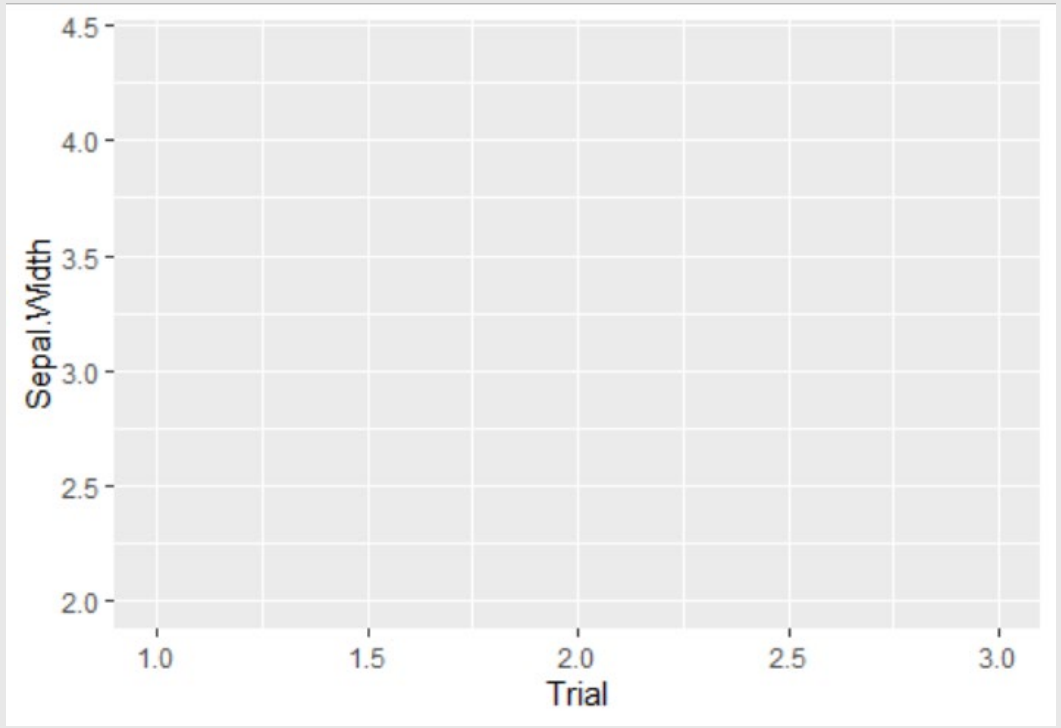
```
df  %>%
ggplot(., aes(x = x, y = y, *= var1) +
```



II. Structure

1. Data
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ggplot(., aes(x = x, y = y, *** = var1**) +

- Considerations
  - Variables are mapped to visual properties (aesthetics)
  - Choosing the aesthetic (*)
    - Color
    - Fill
    - Size
    - Shape
    - Linetype
    - Transparency
  - Is the Continuous or Discrete?
  - What are you mapping to?

II. Structure

ggplot(., aes(x = x, y = y, *** = var1**) +

- Arguments
  - Mappings can be set in ggplot()
    - ggplot(.,aes(color = var1))
  - Mappings can be set in individual layers
    - geom_point(.,aes(color = var1))
  - What is outside of the mapping will be interpreted literally
    - geom_point(.,aes(color = 'var1'))
  - Levels of the mapping are set in scales, else:
    - (.,aes(), color = 'black')

II. Structure

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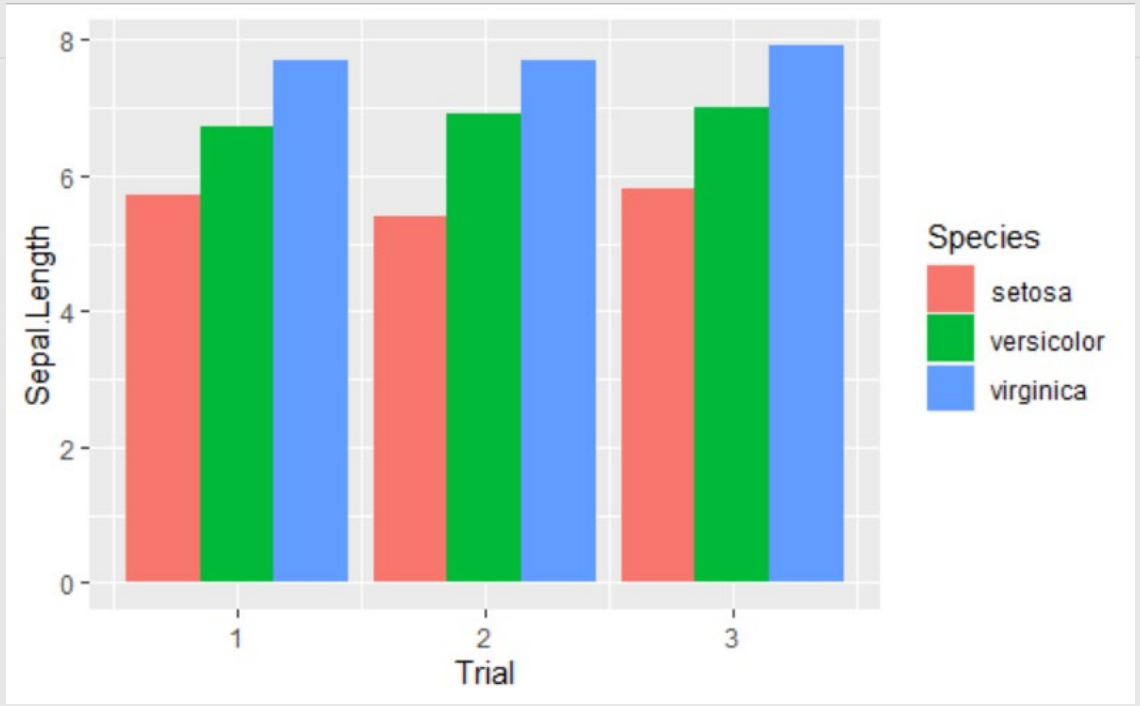
```
df  %>%
ggplot(., aes(x = x, y = y, * = var1))+
geom_*(...) +
```



II. Structure

geom_*(...) +

- Considerations
  - What kind of visual representations (*) are the best approach?
  - Types of Geometry
    - Reference Lines
    - Barcharts
    - Dots and points
    - Boxplots
    - Heatmaps
    - Maps
    - Density
    - Polygons
    - Jitters
    - Error Bars
    - Text and Labels

II. Structure

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Foundation: Graph Attributes

II. Structure

geom_*(...) +

- Arguments
  - Over 40 individual geoms
  - geom_*()
    - geom_point()
    - geom_hist()
    - geom_bar()
    - geom_col()
    - geom_tile()

- Can build individual mappings within geoms_*()
- Can add multiple geometries as annotation layers
- Know the defaults

  geom_*(mapping =, data =, stat = , position =)

II. Structure

1. Data
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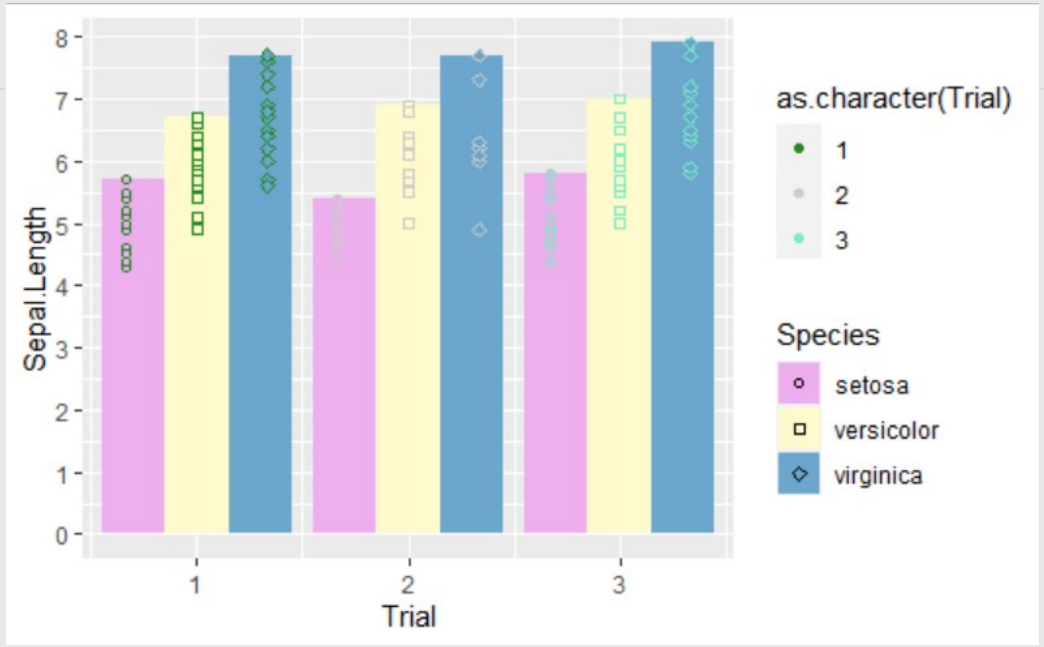
```
df  %>%
ggplot(., aes(x = x, y = y, * = var1))+
geom_*(…) +
scale_*_*(…) +
```



II. Structure

scale_*_*(...) +

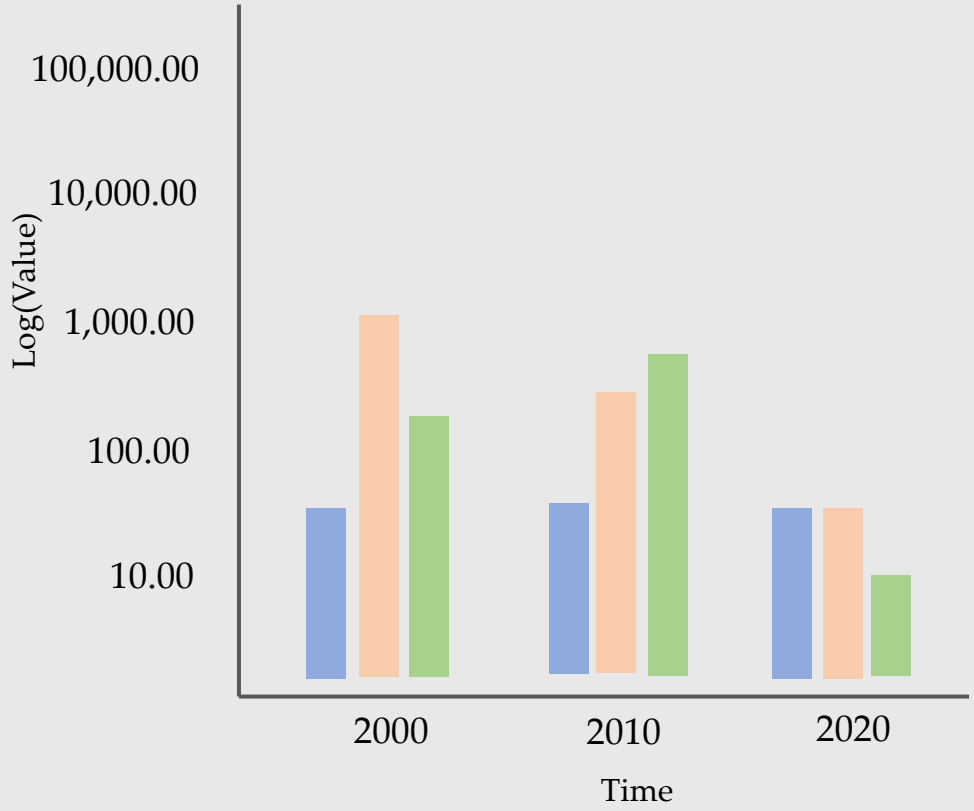
- Concept
  - Specify Data and Mappings
  - Set arguments for coordinates (*)
    - x
    - y
  - Set arguments for mappings (*)
    - color
    - fill
    - alpha
    - linetype
    - … and many more
  - Different calls for discrete and continuous data types
  - Commonly used defaults are prebuilt

II. Structure

scale_*_*(...) +

- Arguments

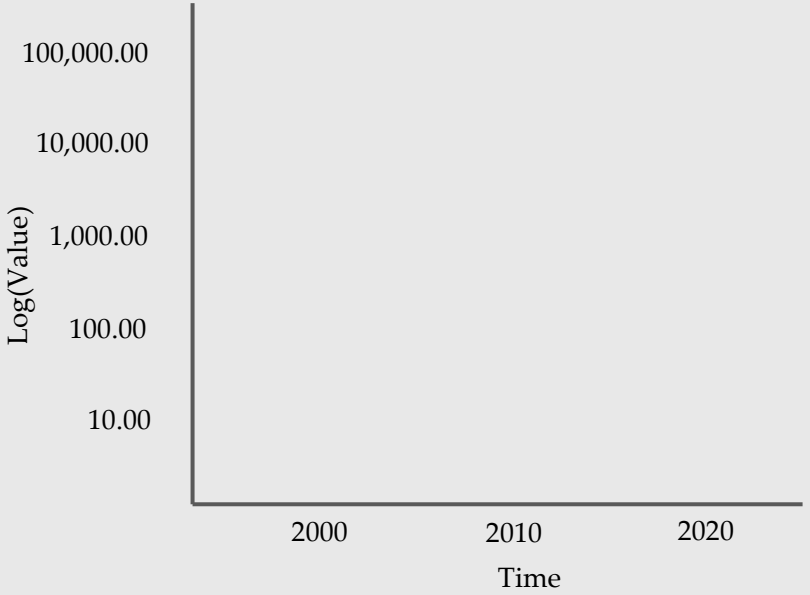
```
scale_*_*(
 name = ,
 breaks = ,
 values = ,
 labels = ,
 limits = ,
 trans = ,
 guide = ,
 position = ,
 ….)
```



II. Structure

scale_*_*(…) +

- Standard Axis Scales
  - scale_x_continous(…)
  - scale_y_continous(…)
  - scale_x_discrete(…)
  - scale_y_discrete(…)
- Pre-Built Custom Axis Scales
  - scale_*_log10(...)
  - scale_*_reverse(...)
  - scale_*_sqrt(...)
  - scale_*_datetime(…)
  - … and many more



II. Structure

scale_*_*(…) +

- Standard Alpha Scales
  - scale_alpha_continous(…)
  - scale_alpha_discrete(…)
- Standard Shape Scales
  - scale_shape_continous(…)
  - scale_shape_discrete(…)
- Standard Linetype Scales
  - scale_linetype_continous(…)
  - scale_linetype_discrete(…)
- … and many more Standard
- … and many more Pre-Built

II. Structure

scale_*_*(…) +

- Standard Color Scales
  - scale_color_continous(…)
  - scale_fill_continous(…)
  - scale_color_manual(…)
  - scale_fill_manual(…)

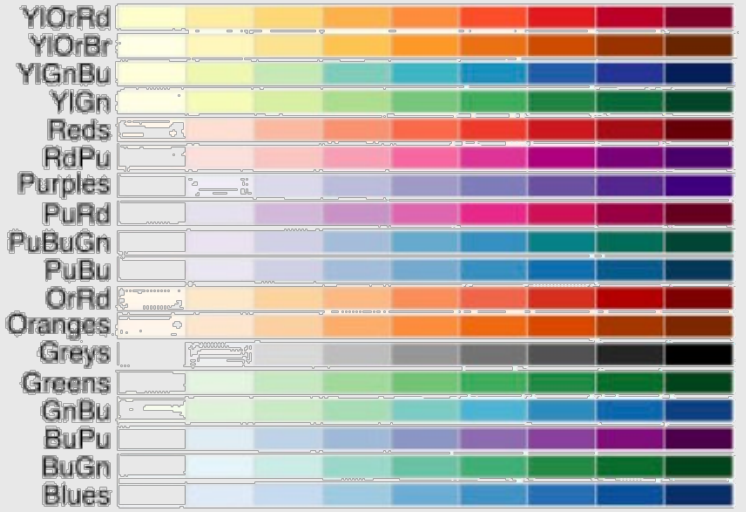
- Pre-Built Custom Color Scales
  - scale_*_brewer(...)
  - scale_*_gradient(...)
  - scale_*_gradientn(...)
  - scale_*_viridis(…)
  - … and many more

II. Structure

scale_*_*(…) +

- Standard Scale – specify colors
  - scale_color_manual(values = c(‘red’, ‘green’, ‘blue’)

- Pre-Built Custom Color Scales
  - scale_*_brewer(
    type =,
    palette = ,
    direction = ,
    aesthetics =)
  - scale_color_brewer(palete = ‘set2’)



II. Structure

1. Data
2. Function
3. Coordinates
4. Mapping
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7. **Facets**
8. Themes

```
df  %>%
ggplot(., aes(x = x, y = y, * = var1) +
geom_*(….) +
scale_*_*(…) +
facet_*(…)
```

II. Structure

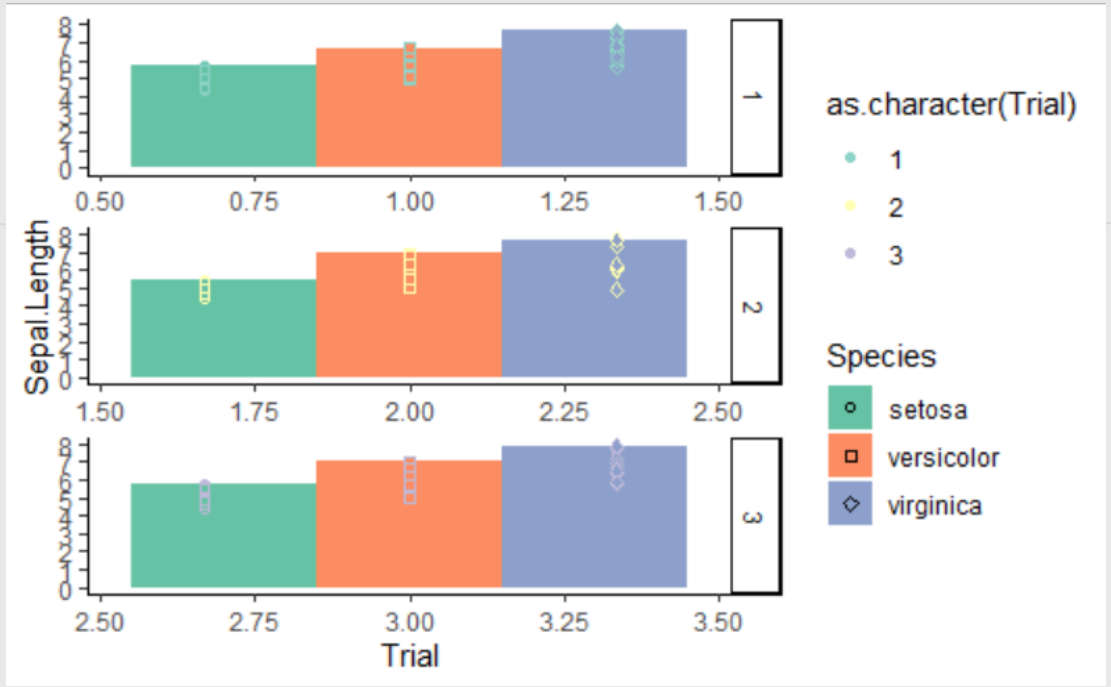
facet_*(…) +

- Concept
  - Highlight levels in data through multiple panels
  - facet_wrap(…)
    - creates a ribbon of levels
  - facet_grid(…)
    - creates a matrix of rows and columns of variable combinations
- Arguments
  - nrow =,
  - ncol =,
  - scales = ,
  - shrink =,
  - labeller = ,
  - strip.position = ,
  - …)

II. Structure

1. Data
2. Function
3. Coordinates
4. Mapping
5. Geometries
6. Scales
7. Facets
8. **Themes**

```
df  %>%
ggplot(., aes(x = x, y = y, * = var1) +
geom_*(….) +
scale_*_*(…) +
facet_*(…) +
theme(…)
```



II. Structure

theme(…)

- Concept
  - Encompasses ALL the options of ggplot2:: plot 'Elements'
  - 4 main modifiers
    - line: all line elements
    - rect: all rectangular elements
    - text: all text elements
    - title: all title elements (including: plot, axes, legends..)
  - Pre-built themes available
    - theme_bw(…)
    - theme_grey(…)
  - ggthemes::
    - a package with a wider selection of Pre-Built themes

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Foundation: Graph Elements

II. Structure

theme(…) +

- Argument
  - The main modifiers:
    - theme(
      text* = element_text(),
      panel* = element_rect(),
      axis* = element_line(),
      title* = element_text())
  - where * = …

1. Data

2. Function

3. Coordinates

4. Mapping

5. Geometries

6. Scales

7. Facets

8. Themes

II. Structure

theme(…) +

```
theme(
aspect.ratio,
  axis.title,
  axis.title.x,
  axis.title.x.top,
  axis.title.x.bottom,
  axis.title.y,
  axis.title.y.left,
  axis.title.y.right,
  axis.text,
  axis.text.x,
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  strip.switch.pad.grid,
  strip.switch.pad.wrap,
  ...,)
```
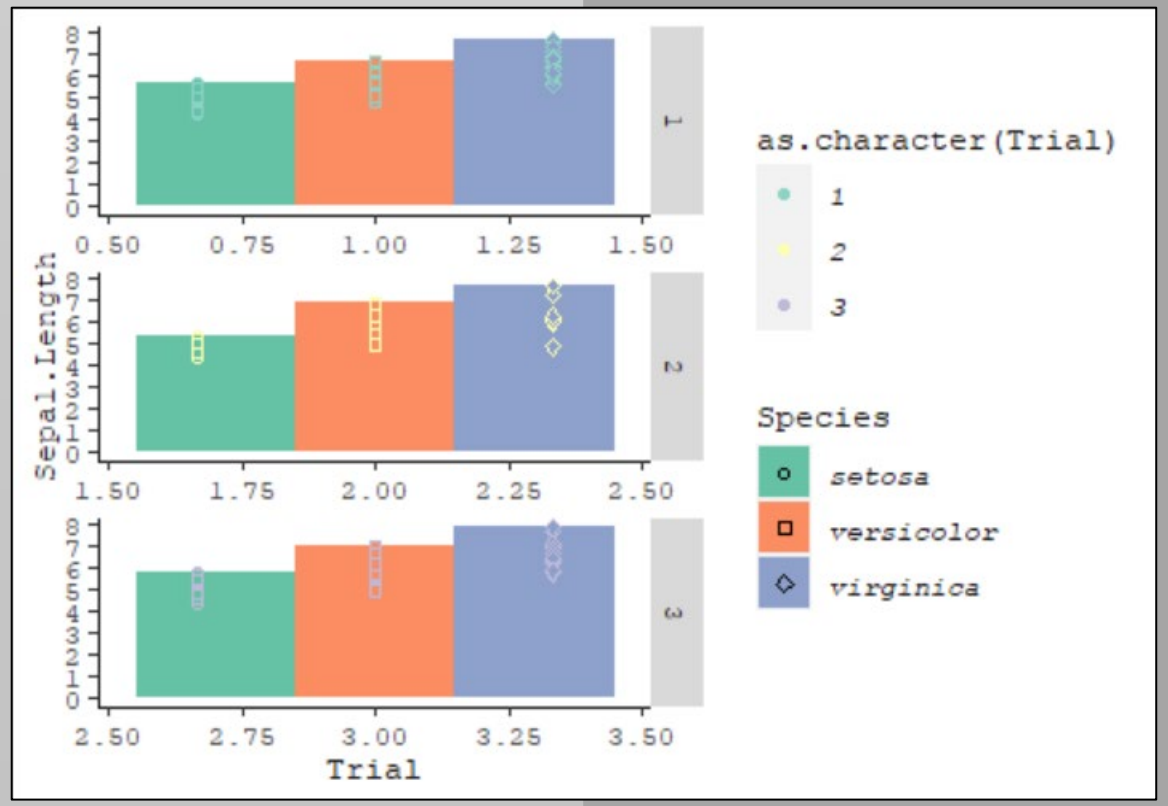
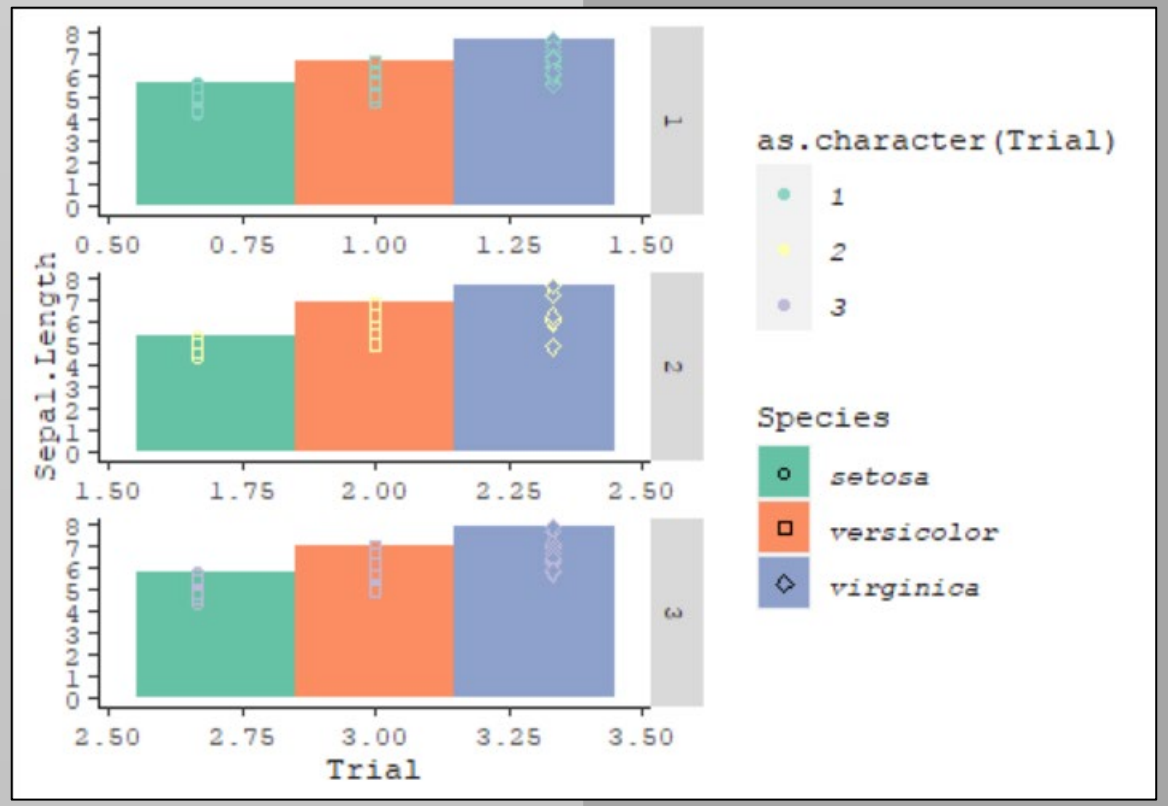

III. Application



Sketch

Story

III. Application



- Facetted Width and Length
- Bargraph
- Trial axis breaks as '2010', 2015', '2020'
- Y axis at 2, 4, 6, 8
- Choose a different palette for species
- Ditch the points, and accompanying scale
- Dodge position
- Species in italics
- No grey in facet
- New font

Sketch

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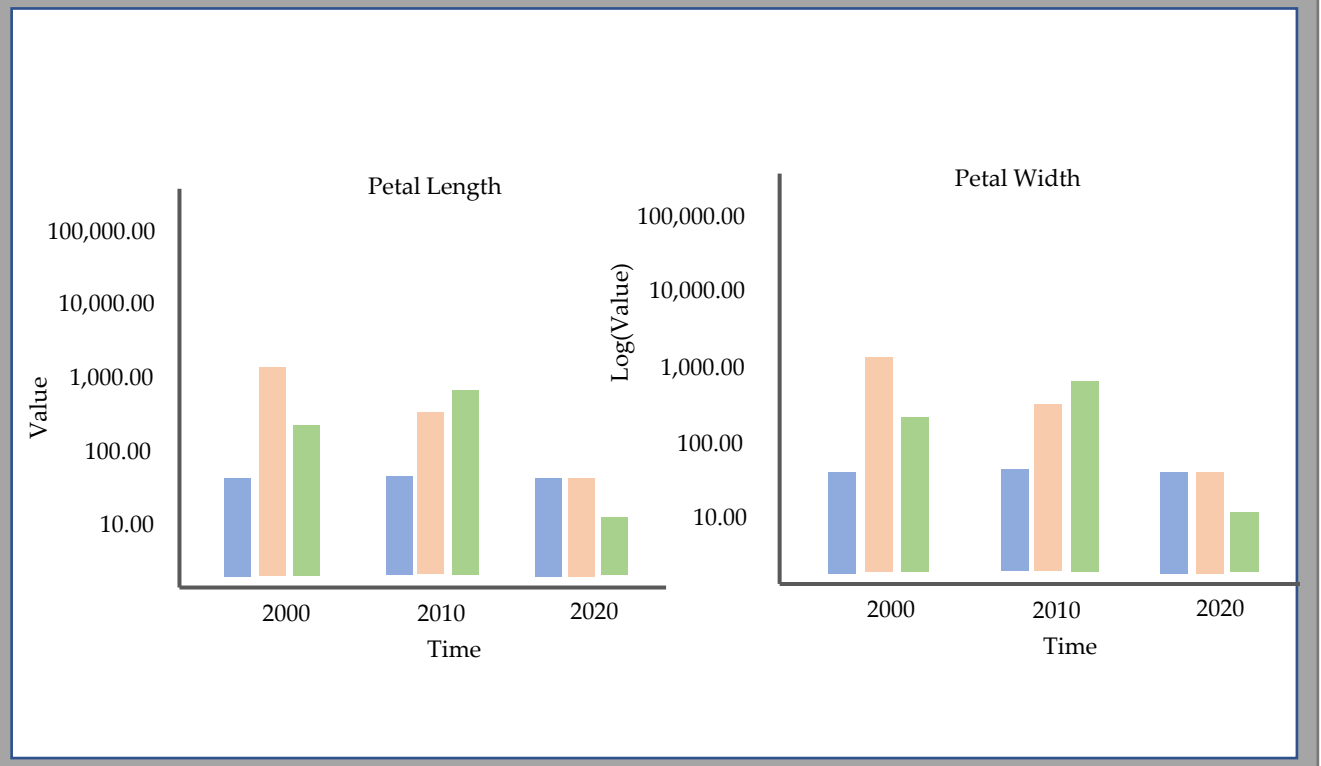
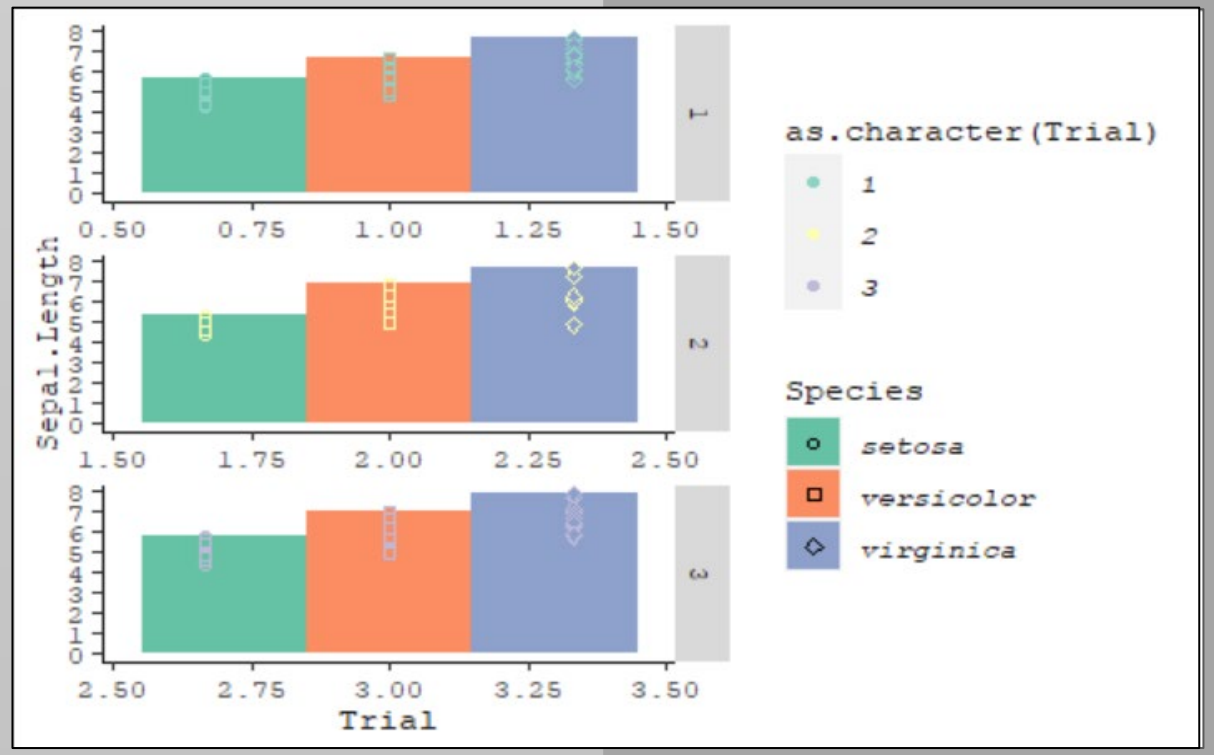
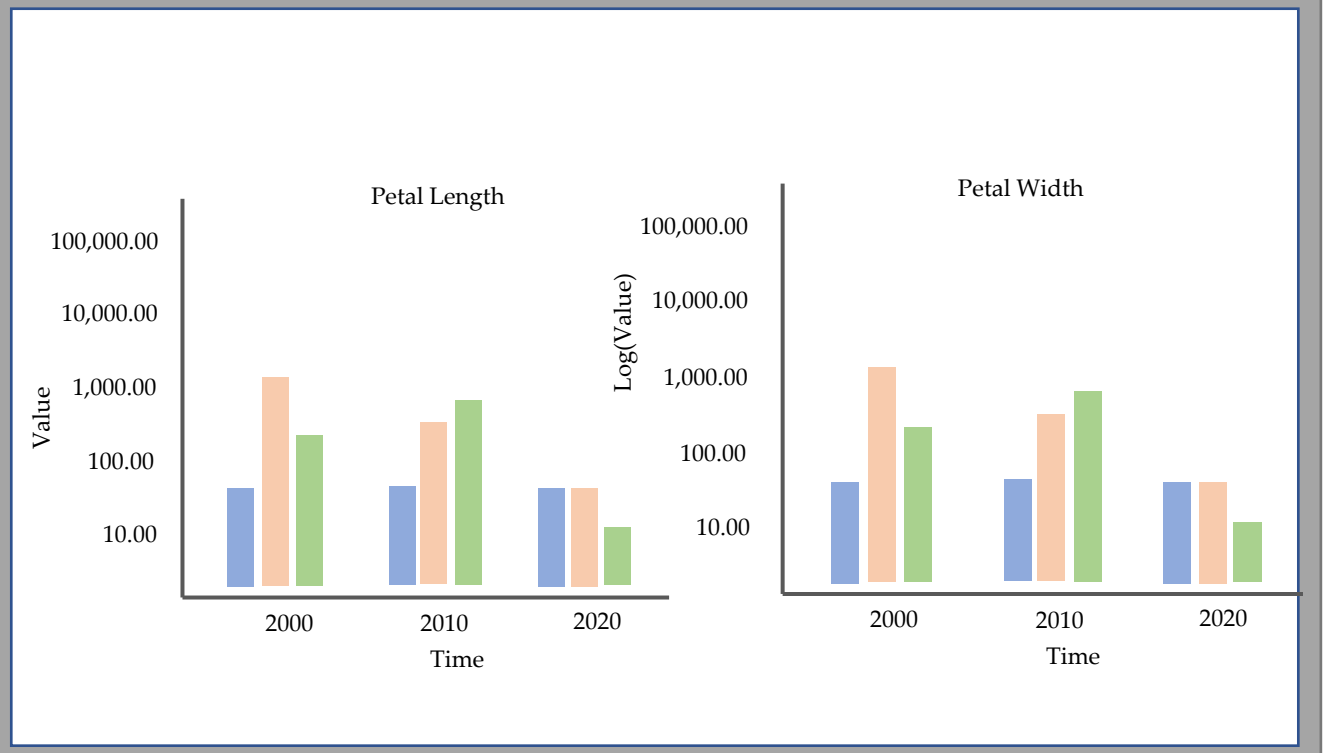


Sketch → Story

III. Application

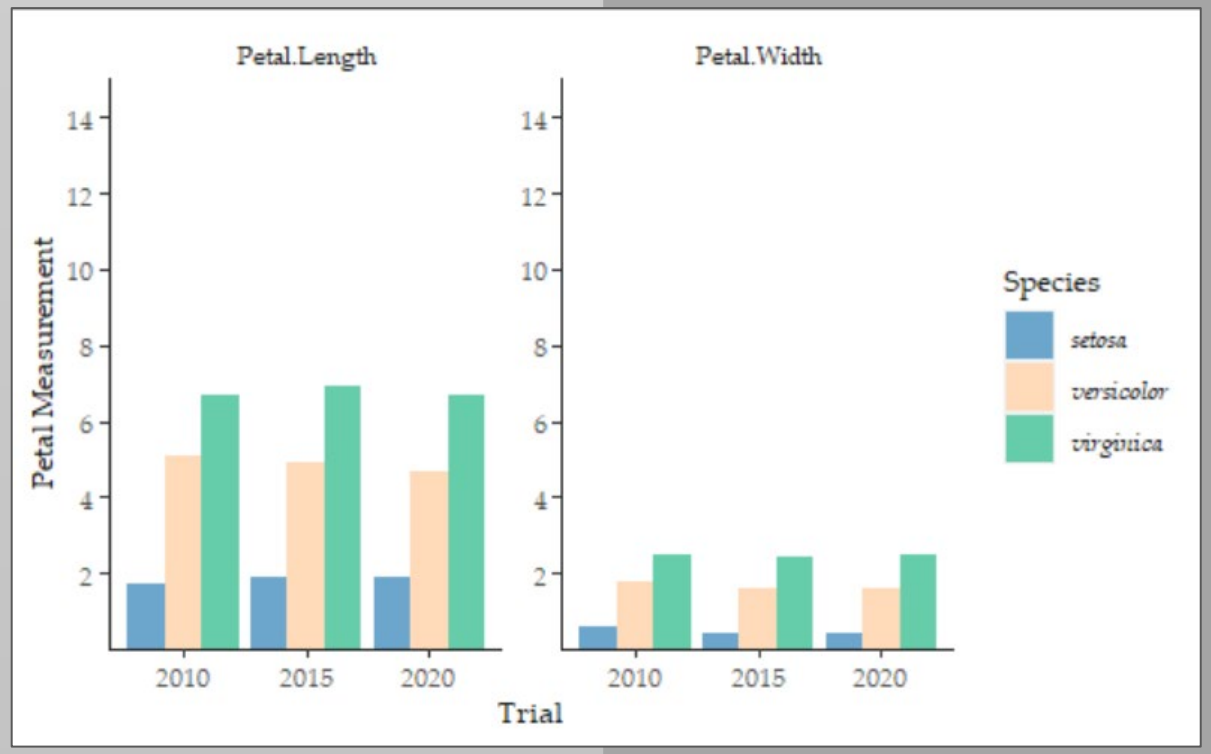


Sketch

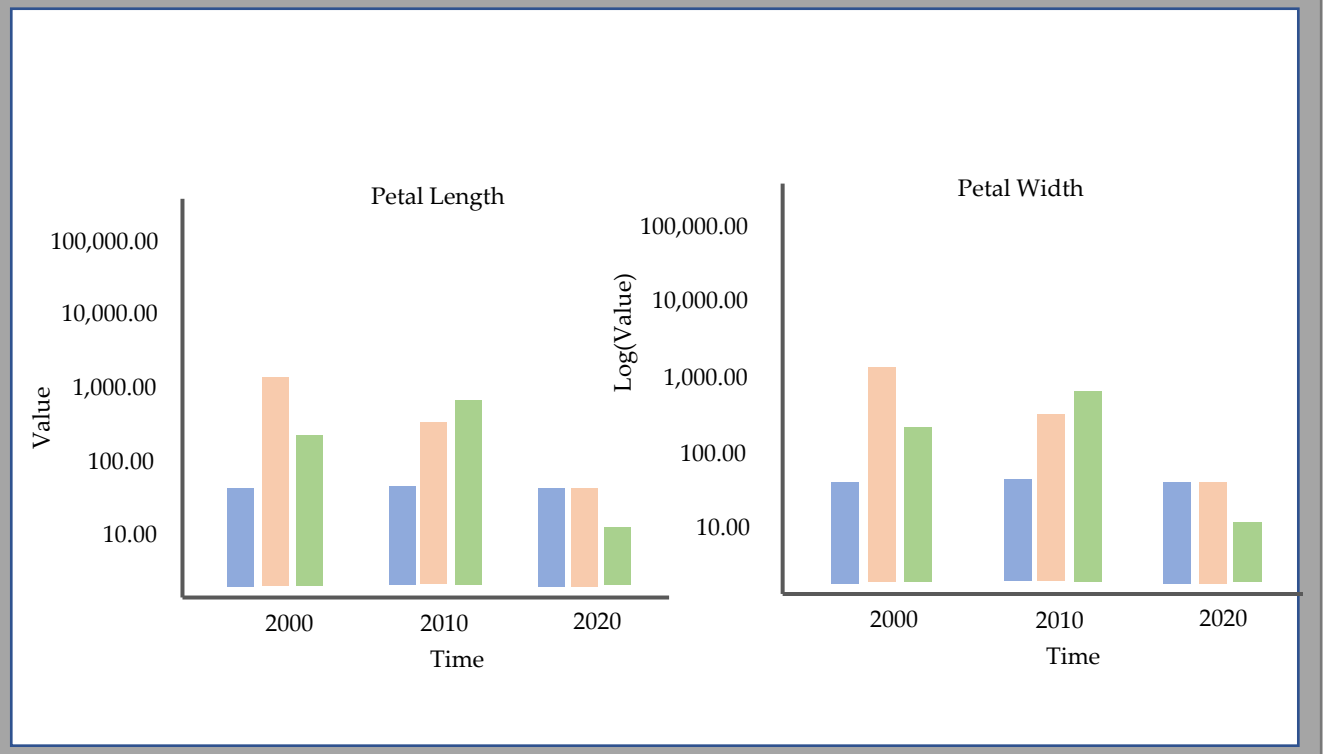


Story

III. Application

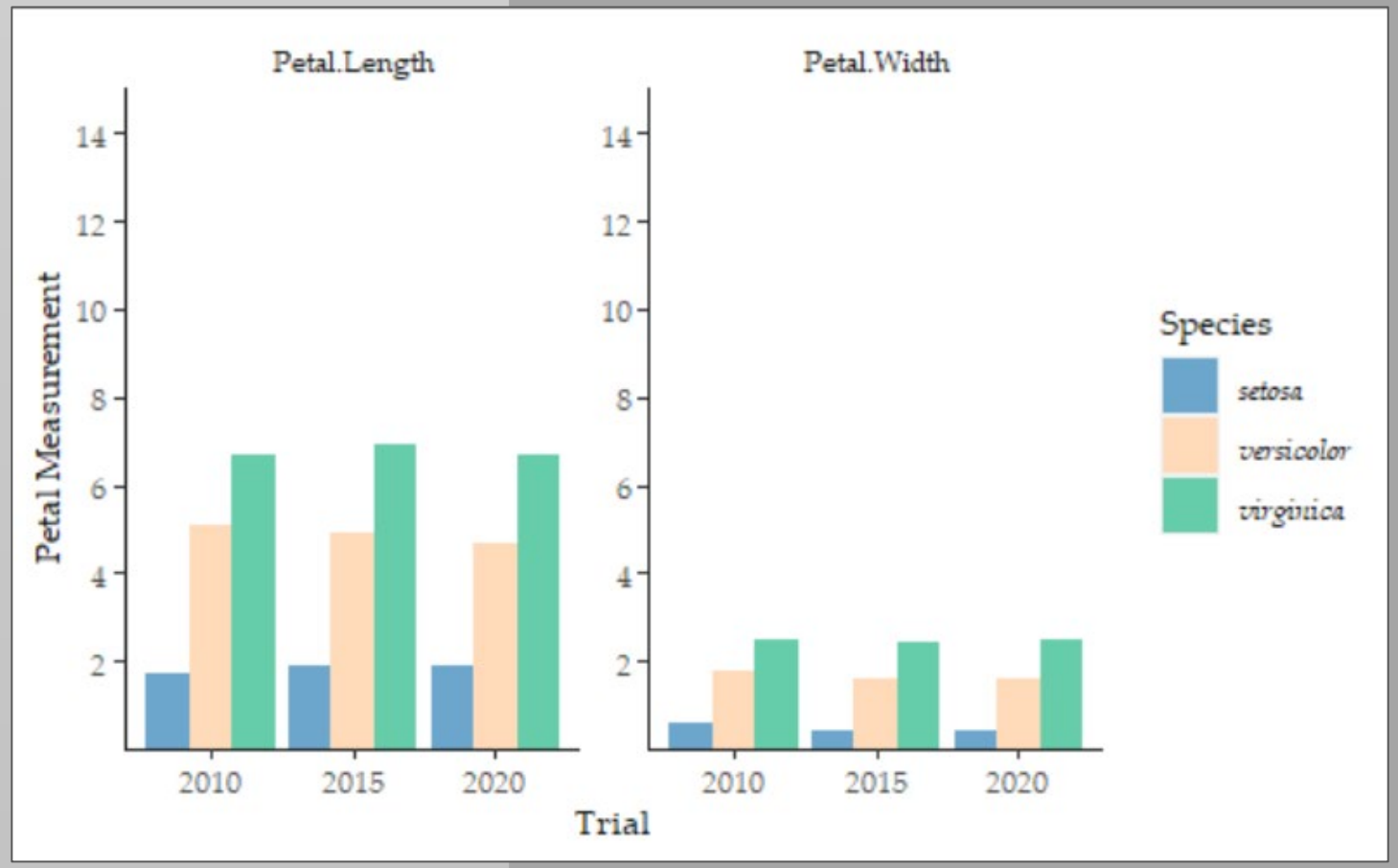


Polished



Story

III. Application



Polished

This is just one round of editing!
What else would you change???

Conclusions

Troubleshooting

- Class of data: counts or continuous data?
- Layer, layer, layer, order matters
- What are the arguments within the function
  - Change the default or consider an alternate geom/function
- Are you invoking a discrete call on continuous data?
- Did you set color when you meant fill?
- Did you specify the multiple arguments for the same item?
  - The last one will be what is seen, check your code.
- Is the default of the function to use a count transform?

Conclusions

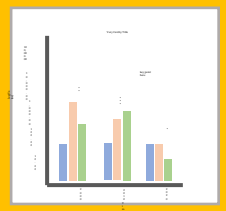
Resources for working in R

- ggplot2.tidyverse/org
- ggplot2-book.org/
- www.r-graph-gallery.com/
- tidytuesday podcast and webpage
- Esquisse and Colors Add-Ins
- Thomas lin Pedersen – ggplot2 – two-part series
- Stackoverflow

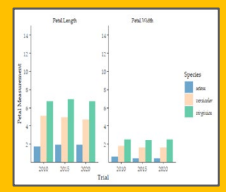
Conclusions

Today's Goal

- Understand how to develop graphics that:
  - Effectively tell a story
  - In ggplot2 (and some tidyverse)
  - Are refined or highly refined.



ggplot(…)



- Github: github.com/meghartwick/
- LinkedIn: /meghan-hartwick-83291551/
- Twitter: @HartwickMeghan

'The question in R is not if it can be done, but how.'

Questions?